

Puccinia ON GROUNDSEL, WITH TRIMORPHIC
TELEUTOSPORES.

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(Communicated by J. H. Maiden.)

(Plates XXXIV.-XXXVI.)

A specimen of Groundsel Rust was sent to me by Mr. Rodway, of Hobart, Tasmania, and found by him there on the 21st April of the present year. The aecidial-stage of the Groundsel Rust is common enough, at least with us at the Royal Horticultural Gardens, Burnley, but as he informs me this is the first and only instance in which he has found the black rust with teleutospores. At present, and indeed throughout the year, there is plenty of Groundsel with aecidia at the Royal Horticultural Gardens, but I have hitherto failed to find any teleutospores, and they are here recorded for the first time in Australia on Groundsel. But last year* I described a *Puccinia* on *Erechtites*, a genus closely allied to *Senecio*, received from Mr. Robinson, of Ardmona, and on comparing the two forms I find that the Groundsel Rust is very similar.

DESCRIPTION.

I. *Aecidiospores*.—Aecidia forming blister-like swellings on stem and branches, on upper and undersurfaces of leaves, on flower-head stalks and involucre, causing discolouration and distortion and usually surrounded by paler green tissue; they are disposed in clusters without any definite order.

Pseudoperidia round, sometimes oval, with white, scalloped everted edges; before opening tubercular.

Aecidiospores spherical, oval or angular, orange-coloured, smooth, average 14-16 μ in dia. or 14-17 \times 12-16 μ . Very common all the year round, except during middle of summer.

* Proc. Roy. Soc. Vict. Vol. vii. N.S. pp. 214-221 (1894).

II. *Uredospores*—not known.

III. *Teleutospores*.—Sori for a long time covered by epidermis, then bursting through and epidermis usually thrown off, or remaining in shreds and patches, intermixed or running parallel with aecidia, black, convex, often confluent in elongated lines, causing swelling of stems, branches, leaves and flower-head stalks and attacking flower-heads.

Teleutospores chestnut-brown, pedicellate, elongated, slightly constricted at middle, variously shaped but usually elongated clavate; upper cell deep chestnut-brown, rounded or somewhat oval, scoop-shaped or truncated, and thickened at apex, $17\text{-}32 \times 15\text{-}25 \mu$; lower cell usually paler in colour, rounded at base or tapering, often elongated relatively to upper, $18\text{-}38 \times 12\text{-}20 \mu$.

Size of teleutospore, $36\text{-}63 \times 15\cdot5\text{-}25 \mu$.

Unicellular and tricellular teleutospores occasionally found.

Unicellular—elongated oval or somewhat elliptical, apex rounded or pointed and usually thickened, smooth, stalked, varying in colour from pale yellow to golden yellow and chestnut-brown, and sometimes colourless at apex. $29\text{-}44 \times 13\text{-}17 \mu$.

Pedicel colourless, persistent and somewhat longer than spore.

Tricellular—elongated club-shape, and generally resembling ordinary teleutospores except in size. $48\text{-}73 \times 22\text{-}25 \mu$.

Pedicels decidedly persistent, pale yellow tint to transparent, sometimes longer than spore, occasionally 63μ , usually stoutish, 5 to 9μ broad.

Aecidiospores on stems and branches, extending from base of stem to topmost flower-head, on upper and undersurface of leaves.

Teleutospores on stems, branches, leaf-stalks, leaves and flower-heads.

On *Senecio vulgaris*, L. Aecidiospores all the year round. New South Wales, Victoria, Tasmania. Teleutospores April, Domain, Hobart, Tasmania (Rodway, 64). Aecidiospores almost all the year round and teleutospores, April to July only in Victoria.

1. The average size of the aecidiospores from Victorian specimens of Groundsel is rather more than from Tasmanian specimens,

which, however, are accompanied by teleutospores. It is not to be inferred on that account that the production of teleutospores intermixed has any influence upon the size of the spores, for I find that the uredospores of *Puccinia pruni*, Pers., are just as large on a leaf producing them alone as when intermixed with teleutospores.

The late Dr. Ralph in a paper "On the *Accidium* affecting the *Senecio vulgaris*, L., or Groundsel,"* stated that he was able to trace by the use of strong carbolic acid the fine yellow sporular matter into the covering of the seed, the seed itself and the hairs of the pappus. It is interesting, as he points out, to find this in the fruit and its appendages, since the hairy pappus surmounting it would thus carry the fungus far and wide. I have found yellow colouring matter in the hairs of the plant, but have been unable to associate it with the fungus.

The suggestion in the same paper that the source of rust in cereals may be found in the Groundsel, taking the place of the Barberry bush in other countries, is rendered highly improbable from the fact, apart from other considerations, that the teleutospores proper to itself have now been found on the Groundsel, along with the aecidiospores.

III. It has been shown by Dr. P. Dietel† in the case of an allied fungus, *Puccinia senecionis*, Lib., that both kinds of spores—aecidiospores and teleutospores—are produced from one and the same mycelium, just as in *Puccinia graminis*, Pers., the uredospores and teleutospores are similarly produced, so that probably here too aecidiospores and teleutospores have a common origin.

CLASSIFICATION.

This fungus belongs to the group *Pucciniopsis*, Schroet., having aecidiospores and teleutospores on the same host-plant, and the question naturally arises as to what species of *Puccinia* it belongs, seeing that the *Compositae* have such a wide distribution,

* Viet. Nat. viii. No. 2, 18 (1890).

† Zeitsch. f. Pflanzk. Vol. iii. Pt. 5, 258 (1893).

and the common Groundsel is likely to have some well-known rust upon it. Groundsel is an imported weed, probably from Britain, and yet curiously enough the very common Groundsel rust of the old country (*Coleosporium senecionis*, Fries) has not yet been met with here.

In Plowright's "Monograph of the British Uredineæ and Ustilagineæ" the following three Puccinias are given as occurring on species of *Senecio*, but none of them on *S. vulgaris*—

P. glomerata, Grev., (thought to be the typical *P. expansa*, Link).

P. senecionis, Lib.

P. schoeleriana, Plow. & Mag.

The two former belong to the *Micro-puccinia* or those which have teleutospores only, and the latter to the *Hetero-puccinia*, in which there are the three kinds of spores, the aecidiospores being on one host-plant and the uredospores and teleutospores on a different host-plant. Assuming that the complete life-history of the above species is known, our fungus belongs to a different group, but on the Continent of Europe *P. senecionis* is known to produce aecidiospores as well,* and therefore it might be a similar species to ours. But the sori are brown, not black, and that excludes it, while on *P. glomerata* the teleutospores are too small for the present species, and the colourless papilla surmounting the upper cell is absent from ours. So that there appears to be no corresponding fungus on British species of *Senecio*.

Turning now to Farlow and Seymour's "Host-Index of the Fungi of the United States," the following are given on species of *Senecio* there, and here again *S. vulgaris* has only the common British rust already mentioned:—

Aecidium compositarum, Mart.

A. senecionis, Desm.

Puccinia conglomerata, Schm. & Kze.

The Puccinias (for there are several) of which *A. compositarum* is regarded as a stage, belong for the most part to the *Hetero-*

* See Dietel in Zeitsch. f. Pflanzenk. Vol. iii. Pt. 5, 259 (1893).

puccinia, and may therefore be dismissed, so that *P. conglomerata* has only to be considered; of which *A. senecionis* is the recognised aecidial stage. This aecidium is given by Dr. Cooke in his "Handbook of Australian Fungi (p. 342) for New South Wales and Victoria" for *Senecio*, but no species is mentioned; still the presumption is that we have here its Puccinia-stage and so resemblances and differences will have to be carefully noted. The principal points of difference in the aecidial stage are that the aecidia of the Groundsel rust are on pale green spots, not on brown, and are not margined with black, but otherwise there is general agreement, except that their spores are rather smaller. It is in the Puccinia-stage, however, that the differences are most marked, and for convenience may be shown in tabular form:—

	<i>P. conglomerata.</i>	<i>P. erectitis.</i>
Length of teleutospore	24-52 μ	36-63 μ .
Breadth	14-26 μ	15-25 μ . (agree).
Apex	{ surmounted by pale or colour- less papilla..... }	{ none.
Length of pedicel	{ short or moder- ately long }	{ long.
Persistence	very deciduous ...	decidedly persistent
Thickness	very slender	moderately stout.
Colour	hyaline	often yellow tint.

While a solitary character, such as the relative length of the stalk, or its persistence, would not justify specific rank, still the aggregate of relatively fixed characters, such as the apical papilla, the length and persistence of the stalk, form specific distinctions.

Finally, Dr. P. Dietel gives critical notes on all Puccinias occurring on *Senecio* and allied Compositæ in his paper on "*Puccinia conglomerata* und die auf *Senecio* und einigen verwandten Compositæ vorkommenden Puccinien."* He remarks there that recent writers have placed many different species in *P. conglomerata* and considers that *P. senecionis*, Lib., and *P. expansa*,

* Hedwigia. Bd. xxx. 291 (1891).

Link, should be raised to specific rank. The Puccinias which he enumerates as occurring on *Senecio* are:—*P. conglomerata*, *P. senecionis*, *P. expansa* and *P. uralensis*; *P. trauzschelii* is also given, but it is now regarded as a variety of *P. conglomerata*. In *P. uralensis** the sori are hypophyllous, the teleutospores are much shorter (36-43 μ), and no aecidiospores are known, so that the distinctness of this species is still maintained. When the proper season comes round, infection experiments will be carried out mutually on *Senecio vulgaris* and *Erechtites quadridentata*.

TRIMORPHIC TELEUTOSPORES.

There are three forms of teleutospores in this species, as already stated—normal or uniseptate, aseptate and biseptate.

A similar case was recorded by W. B. Grove† in *Puccinia betonica*, DC., belonging also to the *Pucciniopsis*, in which he found one-celled, two-celled and three-celled teleutospores. Since then several similar cases have been brought to light, and even four-celled spores have been observed in *Puccinia graminis*, Pers. In *Puccinia saccardoii*, Ludw., an Australian species on *Goodenia geniculata*, Dr. Ludwig‡ records the occurrence, among the normal teleutospores, of unicellular and tricellular spores, sometimes of enormous size, and occasionally singular horn-like branching spores, resembling those of *Phragmidium obtusum*. The whole subject is very fully and ably discussed by Dr. P. Dietel in his paper on “Beiträge zur Morphologie und Biologie des Uredineen.”§ The one-celled spores are commonly known as mesospores, and various views are held as to their meaning. Winter|| regards them simply as unicellular teleutospores and Sorauer¶ considers them as transition forms between uredospores

* Zeitsch. f. Pflanzk. Vol. ii. Pt. 2, 104 (1892).

† Gardener's Chronicle, Vol. xxiv. p. 180 (1885).

‡ Hedw. xxviii. pp. 362, 363 (1890).

§ Bot. Centralb. Vol. xxxii. (1887).

|| Die Pilze, Vol. i. p. 133 (1884).

¶ Pflanzenkrk. Vol. ii. p. 213 (1886).

and teleutospores, but on this view they ought to be more general and not confined to individual species.

P. Magnus* considers, on the other hand, that the uredospores have developed out of teleutospores on account of their better adaptation for germination and dissemination, and that those species which have no uredospores never acquired the property of forming them.

Dr. Plowright† considers them as morphologically analogous to the teleutospores of *Uromyces*, somewhat similar to the view of Tulasne,‡ who regards them as reduced teleutospores, the reduction being brought about by the abortion of the lower cell and thus the genus *Uromyces*, characterised by such spores, is to be considered a degraded form of *Puccinia*. There are other considerations, however, such as the nature of the host-plants, which would seem to point to the *Uromyces* as being rudimentary and not reduced forms of *Puccinia*.

In *Puccini pruni*, Pers., the two cells of the teleutospores readily separate and the lower cell is often imperfectly developed, so that the connection between *Uromyces* and *Puccinia* seems to be shown here. In fact, it would appear that even the eminent mycologist Dr. Cooke was misled by this resemblance when he named this very species, sent from Australia on peach and almond leaves, as *Uromyces amygdali*. And if this relationship is accepted, then the term mesospore, as indicating a transition-form between two other kinds of spore, is inappropriate, as it is really between the two genera.

Just as the unicellular or *Uromyces*-like spore links the *Puccinia* on to lower but not necessarily earlier forms, so the multicellular spore foreshadows the more advanced forms of the Uredines, such genera as *Triphragmium* in which the teleutospore is normally three-celled, and *Phragmidium*, in which it may consist of from three to ten superimposed cells. And thus close

* Ber. Deutsch. Bot. Gesell. ix. (1891).

† Brit. Ured. and Ustilag. p. 39 (1889).

‡ Ann. Sci. Nat. 4 Ser. Vol. ii. p. 145 (1854).

and constant observation of the exceptional forms of spores, just as the methodical investigation of exceptional forms of plants or animals may throw light upon the origin of certain phases of life and show that what is abnormal and exceptional at one stage and under certain surroundings, may become the normal under different conditions of existence.

EXPLANATION OF PLATES.

Puccinia on Groundsel.

(All figures except figs. 7 and 10 magnified 600 diameters.)

Plate xxxiv.

- Fig. 1.—Various shapes and sizes of aecidiospore.
 Fig. 2.—Various forms of teleutospore.
 Fig. 3.—Group of teleutospores.

Plate xxxv.

- Fig. 4.—Unicellular spores.
 Fig. 5.—Three-celled teleutospore.
 Fig. 6.—Aecidiospores.
 Fig. 7.—Teleutospores ($\times 115$).

Plate xxxvi.

- Fig. 8.—Teleutospores.
 Fig. 9.—Group of teleutospores.
 Fig. 10.—Unicellular spore: the same ($\times 115$).
 Fig. 11.—Tricellular spores.

CATALOGUE OF THE DESCRIBED COLEOPTERA OF
 AUSTRALIA. SUPPLEMENT, PART I. CICINDE-
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BY GEORGE MASTERS.

Issued separately as a Supplement to the Part.